Real-Time Operator Physiological Monitoring to Drive Human-Robot Interaction (HRI) Design

Lisa Baraniecki
Biomedical Engineer
lbaraniecki@atinc.com

8737 Colesville Rd, Ste. L203
Silver Spring, MD 20910
www.atinc.com
Background

Shared work spaces      Shared or dependent tasks      Shared “mental models”

Shared situation awareness      Affective awareness      Kinetic actions

Human Ability

- Conceptualization
- Manipulation
- Pattern recognition
- Computation
- Expendability

Robot Ability
Limitations

• The capabilities of robots are constrained by interaction limitations
  – Effectiveness of automation is dependent on human control capabilities
  – Robot performance is often dictated by operator skill
  – Interaction is largely dictated by interface design
Art vs. Science

• Interface design is currently more of an art than a science
  – Often based on engineering principles and robot functionality
  – Designers depend on user adaptability
  – Significant training time is currently required
Solution

• Interfaces must account for dynamic changes in interaction parameters
  − Human/Robot/Mission parameters
  − Environment/Dispositions/SOPs/ROEs

• Effective human-robot team interaction must optimize task allocation
  − Exploit strengths and capabilities of humans and machines
  − Compensate for limitations of humans and machines
Efforts in HRI

- DRC Evaluation

- Dynamic Robot Operator Interface Design (DROID) Assessment, Guidance, and Engineering Tool (AGENT)
Primary Task
Secondary Task

Interface

Camera

Local distance display

Secondary task (visual)

Human Inspired. Technology Driven.
Physiological Metrics

• Provide objective assessment of operator state
  - Cognitive and affective state detection
  - Verbal vs Spatial working memory load

• Can be empirically correlated to performance metrics
  - Insight into underlying cognitive/ psychomotor/ affective processes
Findings

Cognitive Workload

Normalized Workload

Instructing
Responding
Waiting

Modality Condition

AA
AV
VA
VV
Adaptable Interfaces

- Support modularity and redundancy
- Customizable to specific mission, operator, and robot configurations
- Able to be reconfigured on the fly
- Automatically reconfigure in response to:
  - Operator state
  - Robot state
  - Environmental factors
Design Ontology (Mission)

- Ontology relates concepts within underlying taxonomy
  - Smart agent software architecture, underlying database and ontology to support automated HRI design guidance
  - Formulate ontologies to allow analysis using an autonomous reasoning agent
  - Set of relationships are of particular importance for analysis
  - Based on scientifically-grounded design principles and validated assessment metrics
Goal

- Based on Multi-disciplinary HRI design process
  - Involve stakeholders early in design process
  - Leverage strengths/weaknesses of humans and robots
  - Act as a translator between humans and robots
  - Mission-centric approach
  - Multi-modal and adaptive interfaces

Cognitive  Motor  Affective

Taxonomy of Human and Robot Skills
Take Home

• HRI should be considered from the beginning influencing robotic design

• Empirically-based methodology is needed

• Operator physiological monitoring can provide objective and quantifiable data to drive HRI design and assessment

• Real-time physiological measures can be used to drive adaptive interfaces
Questions?